Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

SALMON PRICING TRENDS:

A SIMULATION MODEL

Economic and Commercial Analysis

Report No. 53

Fisheries and Oceans
Pêches et Océans

Canada

SALMON PRICING TRENDS: A SIMULATION MODEL

Economic and Commercial Analysis Division

Program Planning and Economics Branch
Department of Fisheries and Oceans
Suite 400 - 555 West Hastings Street
Vancouver, B.C.
V6B 5G3

Report prepared by:

Marvin Shaffer & Associates Ltd.
White Rock, British Columbia

December, 1989

(Department of Fisheries and Oceans
contract no. VPS 88 - 079)

Economic and Commercial Analysis
Report No. 53

90-04882/

PUBLISHED BY:

Scientific Publications
Communications Directorate
Department of Fisheries and Oceans
Vancouver, British Columbia
V6B 5G3

(c)Minister of Supply and Services
Canada 1990
Catalogue Number FS66-5/53E
ISBN 0-662-17702-9
ISSN 0843-5626

Correct citation for this publication:

Department of Fisheries and Oceans. 1989
Salmon Pricing Trends: A Simulation Model.
Economic and Commercial Analysis
Report 53: p. 38

ABSTRACT

This simulation model forecasts long term trends in salmon product prices. Log linear price equations -- by species, product and market area -- are used to relate price trends to trends in per capita income, substitute prices, population, taste changes and total supply.

Cross-price elasticities among salmon species link the price forecasts through the demand side. Further work on the model is required to incorporate price-induced market and product form shifts in order to link the forecasts on the supply side. The parameters used in the model are hypothesized, based on previous work. While preliminary in nature, the model provides a tool for analyzing how trends in key variables, like income, population and supply, may affect future salmon prices.

A copy of the price forecasting model can be obtained by contacting Peter Leitz at (604) 666-6570.

RÉSUMÉ

Ce modèle de simulation permet de prévoir les tendances à long terme des prix pratiqués pour les produits du saumon. Incorporant des équations loglinéaires, qui tiennent compte de variables comme l'espèce, le produit et le secteur du marché, le modèle établit des liens entre les tendances des prix et les tendances du point de vue du revenu par personne, du prix des produits de substitution, de la population, de l'évolution des goûts et de l'offre globale.

Les calculs concernant l'élasticité-prix croisée pour différentes espèces de saumon permettent de relier les prévisions des prix sur le plan de la demande. Il reste à incorporer dans le modèle l'effet de fluctuations du marché attribuables aux prix et de changements dans l'état des produits afin de relier entre elles les prévisions relatives à l'offre. Les paramètres employés dans le modèle sont hypothétiques, étant fondés sur des travaux antérieurs. Bien qu'il s'agisse d'une version préliminaire, le modèle constitue un bon outil pour analyser comment les tendances inhérentes à des variables clés, comme le revenu, la population et l'offre, peuvent influer sur le prix du saumon à l'avenir.

Pour obtenir un exemplaire du modèle de prévision des prix, prière de communiquer avec M. Peter Leitz au (604) 666-6570.

TABLE OF CONTENTS

		Page
EXECUTIVE SUMMARY		v
1.0	**INTRODUCTION**	1
2.0	**THE MODEL**	2
2.1	Basic Price Equation	2
2.2	Products and Market Destinations	6
2.3	Market Linkages	8
2.4	Model Structure	10
2.5	Model Limitations	12
2.6	Areas for Further Work	13
3.0	**ASSUMPTIONS FOR INITIAL RUN**	15
3.1	Demand-Related Parameters	15
3.2	Supply-Related Parameters	22
3.3	Demand-Determining Variable Forecast	22
3.4	Supply-Determining Variable Forecast	23
4.0	**RESULTS**	26
4.1	Initial Run	26
4.2	Sensitivity Analysis	29

EXECUTIVE SUMMARY

- A simulation model to develop long term forecasts of salmon prices is developed in this study. Specific forecasts and sensitivity results are presented. However, the model is preliminary in nature and could be enhanced in future work.

- Price equations are developed for different species, product forms and market destinations. The equations are derived by equating demand and supply, with demand specified as a function of per capita income, substitute prices, own prices, taste and population changes, and supply specified as a sum of "exogenously-determined" B.C. and rest of the world supply.

- Market linkages are developed through substitute salmon species-cross price elasticities of demand. In an enhanced model there would also be linkages on the supply side through price differential market or product form response functions.

- The model is programmed in Lotus 1-2-3, with four main blocks: the parameter input block, the demand-determining variable input block, the supply input block and the price equation block. Macro menus are available to facilitate input entry, calculation and printing of results.

- The model is subject to certain limitations. It could be enhanced by making supply responsive to price differentials, by further analysis of some key parameters for which there is currently only limited information (e.g. cross-price elasticities), and by further review of the structure of the model (e.g. selection of market areas).

- The base case results indicate a small rate of price increase for most products, because of rising incomes and populations. However, farmed prices and the prices of competing wild salmon show marked initial price reductions because of the impact of higher supply, particularly Norwegian supply.

- Sensitivity tests indicate the impact of key parameters. High income elasticities raise the price forecast; higher own price elasticities tends to dampen price changes; and higher cross-price elasticities tend to bring the forecast changes of competing products closer together. Greater positive taste changes and population growth both tend to raise the price forecasts.

1.0 INTRODUCTION

The purpose of this report is to describe a simulation model designed to facilitate forecasting trends in salmon product prices and to present some specific forecast results developed with the model.

The key elements of the model are market equations which define price trends based on supply and demand variables, and market linkages which recognize that prices for any one salmon product form or species are potentially interrelated with all others.

The forecast results are based on existing information regarding parameters in the different equations and trends in the independent variables. The emphasis in developing forecast prices was to analyze the importance of different underlying factors and to present plausible ranges of results. Understanding the circumstances under which prices might behave in certain ways was considered as important as the determination of a "most likely" outcome itself.

It should be noted that the model developed in this study is preliminary in nature. Considerably more effort is required to produce a model sufficiently flexible and sophisticated to capture the many interrelationships among salmon prices and markets. Specific areas requiring further work are outlined in section 2.6 of the report.

2.0 THE MODEL

2.1 Basic Price Equation

General price equations are defined for each salmon species, by principal product form and market destination. In each case, the price equation was derived by equating supply and demand in the specific market. The assumed determinants of supply and demand and the assumed functional forms are outlined below.

Demand:- Demand for a particular salmon product is equal to the per capita consumption times the population in the market area. In accordance with economic theory, and the results of numerous empirical studies,[1] per capita consumption is assumed to be a function of per capita income; the relative price of substitute food products (e.g. beef, tuna); the relative price of substitute salmon species; and the price of the product itself. A taste trend variable is also assumed to potentially affect per capita demand. This accounts for shifts in demand independent of the specified income and price variables. A log linear functional form is assumed in accordance with common practice and considerable empirical support.[2]

---

[1] See references, footnote 1, p. 17.

[2] See, for example, the studies cited in footnotes 1 on page 17. They virtually all use log linear functional forms.

In equation form,

$D = C/N * N$

D	-	demand
C/N	-	per capita consumption
N	-	population

$C/N = f\,(Y/N, P_A/P, P_S/P, P) * T$

Y/N	-	per capita income
P_A	-	price of alternative food product
P_S	-	price of competing salmon species
P	-	own price (in market currency and area)
T	-	taste trend variable

(with income and all prices expressed in real terms)

$$\ln D = \ln (C/N) + \ln N$$

$$= a_0 + a_1 * \ln (Y/N) + a_2 * \ln (P_A/P) + a_3 * \ln (P_S/P) + a_4 * \ln P + \ln T + \ln N$$

a_1	-	income elasticity of demand
a_2	-	cross price elasticity (alternative food)
a_3	-	cross price elasticity (alternative salmon)
a_4	-	own price elasticity

Supply:- Supply of a particular product in a particular market area is equal to the sum of B.C. supply and the rest of the world supply. B.C. supply is equal to the landings of the given species times the proportion of landings (adjusted for shrinkage) directed to the product form, times the proportion of the product directed to a particular market area. In principle, the product and market destination coefficients are functions of relative net returns from the different product forms and market areas, though they are treated as exogenous variables in this formulation of the model. Rest of the world supply is also assumed to be exogenous.

In equation form,

$S = S_{BC} + S_F$

$S_{BC} = p * d * L$

S	-	supply into market area
S_{BC}	-	B.C. supply
S_F	-	rest of world supply
p	-	proportion (adj. for shrinkage) of landings into the product form
d	-	proportion of product into the market areas
L	-	B.C. landings

$\ln S = \ln (p * d * L + S_F)$

Price Equation:- The basic price equation is derived by equating supply and demand in logarithmic form. Because the full differential of the logs indicates the proportionate change, the price equation can be expressed in terms of the proportionate change in price as a function of the proportionate change in the underlying demand and supply-determining variables.

In equation form,

$\ln D = \ln S$

$a_0 + a_1 \ln (Y/N) + a_2 \ln (P_A/P) + a_3 \ln (P_S/P) + a_4 \ln P + \ln T + \ln N = \ln S$

Therefore,

$\ln P = - 1/a_4 [a_0 + a_1 \ln (Y/N) + a_2 \ln (P_A/P) + a_3 \ln (P_S/P) + \ln T + \ln N - \ln S]$

Therefore,

$$\dot{P} = -1/a_4 * [a_1 * \dot{Y}/N + a_2 * (\dot{P}_A/P) + a_3 * (\dot{P}_S/P) + \dot{T} + \dot{N} - \dot{S}]$$

where the $\dot{}$ above the variable name refers to the proportionate change

$$(\text{e.g. } \dot{P} = {}^{(dp/dt)}/P)$$

But $\dot{S} = \beta_1 \dot{S}_{BC} + \beta_2 \dot{S}_F$

Where β_1 = B.C.'s share of supply
β_2 = rest of world's share of supply

And $\dot{S}_{BC} = \dot{p} + \dot{d} + \dot{L}$

Therefore,

$$\dot{P} = -1/a_4 [a_1 (\dot{Y}/N) + a_2 (\dot{P}_A/P) + a_3 (\dot{P}_S/P) + \dot{T} + \dot{N} - \beta_1 (\dot{p} + \dot{d} + \dot{L}) - \beta \dot{S}_F]$$

This equation indicates the delivered (c.i.f.) price expressed in the market area currency. To express the price trend in Canadian currency one must adjust for changes in the exchange rate.[1]

$P^* = P * E$

P^* - is the c.i.f. price expressed in Cdn. currency

E - is the exchange rate ($Cdn./$foreign)

---

[1] For this model it is assumed that trends in c.i.f. price indicates trends in the f.o.b. price, i.e. the delivered price less transportation costs. This is an approximation since transport costs need not remain a constant percentage of the delivered price. However, it is done to simplify the analysis.

Therefore,

$$\dot{P}^{*} = \dot{P} + \dot{E}$$

2.2 Products and Market Destinations

The basic price equation described above is used to forecast prices in the principal markets for British Columbia salmon. In Table 1, these markets are listed by species. They were selected on the basis of sales data for B.C. salmon products. For all species except chum, the selected markets typically represent 60 percent or more of the total sales. Not all markets were selected for separate analysis because it was assumed that prices in the smaller markets are largely governed by prices in the principal markets examined. Also, because of their small size, it is unlikely that they would have a significant impact on the weighted average species prices, even if their price trends were to differ from those in the principal market. In the case of chum, there is a large array of markets, none of which individually accounts for a large share of the production. In this case single markets were assumed to represent the behaviour of several. So, for example, the behaviour of prices in French frozen markets is taken to be similar to that shown in other EEC countries which consume this product.

TABLE 1

Principal Product and Market Areas

	Product Form	Share of Total B.C. Production* (percent)
Sockeye	Domestic canned	33.5
	U.K. canned	21.1
	Japan f/f	30.7
Pink	Domestic canned	55.1
	U.K. canned	11.7
	U.S. f/f	1.0
Chum	France f/f	5.0
	Sweden f/f	15.1
	U.S. f/f	5.7
Coho (wild)	Domestic canned	20.5
	Japan f/f	9.4
	France f/f	32.6
Chinook (wild)	Domestic f/f	18.6
	U.S. f/f	26.7
	France f/f	23.8
	Italy f/f	7.4
Coho Farmed	U.S. f/f	N.A.
Chinook Farmed	U.S. f/f	N.A.

*Based on forecast landings and allocation by product form and market destination, provided to the study team by DFO. N.A. - not available separately from wild shares.

2.3 Market Linkages

While separate equations are used to forecast price trends in each market, the prices are interrelated because of potential demand responses to relative market prices. In principle, there is a potential linkage through supply responses to relative prices in different markets, but these are not incorporated in this formulation of the model.

On the demand side, the cross price elasticity of alternative species serves to link different species' prices. A rise in one price (e.g. canned sockeye) relative to a potentially competing salmon price (e.g. canned pink) will reduce the demand for sockeye and raise it for pink. This tends to soften the divergence in price trends between the two species. The competing salmon products for each product form and market area that are assumed in the model are listed in Table 2.

On the supply side, the proportion of landings or production going to different product forms and market areas could link different product and market destination prices within each species. A rise in the price of one product form or market destination relative to the others could increase the supply into that area and reduce supply into the other areas. This would dampen any divergence in price trends within each species. This was not modelled, however, because of time and budget constraints. A first step here would be to incorporate B.C. supply responses. In a complete model, the effect of relative prices on world supply would also have to be considered.

TABLE 2

Competing Salmon Products

	Product Forms	Competing Species
Sockeye	Domestic canned	Pink, Coho
	U.K. canned	Pink
	Japan f/f	Coho
Pink	Domestic canned	Sockeye
	U.K. canned	Sockeye
	U.S. f/f	Chum, Chinook (wild)
Chum	France f/f	Coho (wild), Chinook (wild)
	Sweden f/f	---
	U.S. f/f	Pink, Chinook (wild)
Coho (wild)	Domestic canned	Sockeye
	Japan f/f	Sockeye
	France f/f	Chinook (wild), Chum
Chinook (wild)	Domestic f/f	---
	U.S. f/f	Chinook (farmed), Pink, Chum
	France f/f	Coho (wild), Chum
	Italy f/f	---
Coho Farmed	U.S. f/f	Chinook (farmed)
Chinook Farmed	U.S. f/f	Chinook (wild), Coho (farmed)

The market linkages incorporated into this model are important because they explicitly recognize that salmon price trends are interdependent. One of the advantages of this simulation approach, with hypotheses about the magnitude of different cross price

elasticities, is that the potential significance of this interdependence can be assessed.[1] Strong multicollinearity between different salmon prices has generally made econometric testing of these linkages very difficult.

2.4 Model Structure

The model is programmed in Lotus 1-2-3. It consists of four main blocks, as outlined below.

(i) **Parameter Input Block**: Demand-related parameter values for per capita income elasticities, price elasticities, other food and other salmon cross price elasticities, and annual rate of taste-driven growth in per capita demand are specified by the user. They can vary by product and species, but are assumed constant over the forecast period. Supply-related parameter values include product shrinkage rates.

(ii) **Demand-Determining Variable Input Block**:- Forecasts of the rates of change of population, per capita income and alternative food prices are specified by the user for each country where B.C. salmon is sold. Forecast levels of the exchange rate between Canada and each export destination are also specified.

(iii) **Supply-Determining Variable Input Block**:- Forecasts of B.C. landings of wild salmon, and production of farmed salmon, are specified by the user. These are then converted in the model to forecasts of the supply of B.C. salmon into each product market on the basis of product mix and destination mix assumptions (which are also user definable). Forecasts of non-B.C. supply into each product market are also specified by the user. Forecast total aquaculture production of relevant species from relevant countries can also be user-specified, along with the destination mix. This allows the user to experiment, for example, with a variety of assumptions about the future destinations of Norwegian farmed product.

---

[1] Had supply been modelled as a function of relative prices, the interdependence of prices across different market destinations would have been simulated. This is potentially very important, particularly for a long term model where significant price differences would create an incentive to redirect supply to the higher-valued markets.

(iv) **Price Equation Block**:- The price equations for each product market draw on the input blocks as outlined above to produce ten year forecasts of changes in real prices. Finally, the model uses estimates of current prices to forecast absolute prices ($/kg) based on these rates of change.

The model has simultaneous (or circular) elements. The simultaneous behaviour occurs in the price equations because of the cross price elasticity terms. The prices of competing salmon products depend upon one another.

To run the model, the input blocks must be specified or reviewed and then the spreadsheet calculated enough times for the price equation results to converge to specific annual values. Convergence occurs when one additional calculation does not change the result.

Macro menus have been provided to facilitate input entry and model calculation. They are briefly described below.

- **Location Menu**:- Pressing "Alt" and "G" invokes a menu to go to specific locations within the model. Location choices are parameter estimates, demand determining variables, B.C. landings, world aquaculture supply, and price forecasts.

- **Cross Price Elasticity Menu**:- Pressing "Alt" and "X" allows the user to specify cross price elasticities. As discussed in section 3.1, the model automatically selects consistent values for all species which are substitutes of each other.

- **Calculation Menu**:- Pressing "Alt" and "C" initiates a sequence to calculate the model. The user must select whether to begin a new run or to continue with additional iterations (in case the model has not previously converged). The user will be prompted to select the number of iterations to be performed. The model will perform the calculations, and display key results after the stated number of iterations and after one additional iteration. If both columns are identical, the model has converged and if not, additional iterations should be

performed. In general, with low values of the cross price elasticities (e.g. .1), the model will converge quickly, usually in less than five iterations.

- **Print Menu**:- Pressing "Alt" and "P" displays available choices for printing out some or all of the model.

2.5 Model Limitations

The model is quite general and can accommodate a wide range of assumptions regarding factors determining demand and supply. However, there are significant limitations that the user should be aware of.

First, the log linear functional forms impose certain assumptions about price behaviour that may or may not be valid. This is potentially more serious the more significant the size of the changes in the independent variables.

Second, the structure of the salmon cross-price (substitution) effects is limited. Direct cross-price effects are only incorporated for specific salmon products. Also, while an effort has been made to ensure that corresponding cross price elasticities are consistent with one another, they are fixed over the forecast period.

Third, the supply forecasts are quite simplistic. They do not consider the effect of price on total supply, which may be particularly relevant in the case of farmed production. Nor do they take account of the full complexity of product and market destinations, including the potential endogenous impact of relative market prices.

Finally, inventory change is not incorporated into the model. This was considered appropriate for a long term forecasting model, but does limit its use for year to year forecasting purposes, and may lead to overstating the price fluctuations caused by supply variations in certain markets.

2.6 Areas for Further Work

This model is a preliminary attempt to analyze the many factors affecting price trends over the long term. While it does provide some insights into the potential effects of increasing farmed supply, varying cross-price elasticities, and other factors affecting future prices, the usefulness of the model could be enhanced in a number of ways.

The most important enhancement would be to make supply into different market areas and product forms responsive to price differentials. While there are market structure, contractual, capacity and other "rigidities" that prevent a complete adjustment to different (netted back) prices in different markets, one could expect some supply adjustments as prices (and netbacks) start to diverge.

Three levels of enhancement are required on the supply side. First, the supply of a given product going to different market areas should be responsive to price differentials between markets. Second, the share of production processed into different product forms should be variable, possibly within specified limits and subject to specified lags. Finally, the

supply of farmed product could be made a function of price levels, again subject to specified lags.

Another enhancement of the model would be to analyze, in much greater detail, the theoretical factors and empirical evidence on cross-price elasticities of demand. This parameter is very important in determining how the supply of one product (e.g. farmed chinook) affects the price of another (e.g. wild chinook or coho). Since this is an important policy area, contingent valuation or other techniques could be considered to develop specific estimates for the model.

Even with further research into specific parameters, there will remain considerable uncertainty regarding key factors and key exogenous variables which affect future prices. A further enhancement that might assist in analyzing this uncertainty would be to run Monte Carlo simulations. This would help identify a probable range of results, given the range (and distribution) of possible values for the parameters and exogenous variables.

Finally, this model was developed in a short time frame and warrants review. In particular, the selection of market areas and product destinations should be reconsidered. Greater flexibility in the functional forms and the relationship between cross price elasticities could be considered. Also linkage to -- or development of -- the landed price implications of these product price forecasts could be developed.

3.0 ASSUMPTIONS FOR INITIAL RUN

3.1 Demand-Related Parameters

A number of salmon demand studies[1] were reviewed to develop "reasonable" estimates or ranges for the demand-related parameters in this model. All of these studies were econometric in approach, with the exception of Anderson (1988), which used the results of a survey to determine substitutability between wild salmon and farmed product. The majority of the econometric papers reviewed include the application of analytical results to forecast prices over varying time horizons (Lin et. al., Leitz, Barnes and DeVoretz, 1980). The Anderson paper attempted to predict the net impact (for 1990 and 1995) on prices of increased demand and increased supply of (particularly farmed) salmon

---

[1] Anderson, James L., Current and Future Market for Salmon in the United States, University of Rhode Island, 1988.
Barnes, J.A., Canadian Domestic and Export Salmon Demand Models Estimation Results and Price Forecasts, November 1987. (Based on DeVoretz June 1988, noted below)
DeVoretz, D.J., Econometric Demand Models for Canadian Salmon, May 1980.
DeVoretz, D.J., Export Demand for Canadian Salmon: EEC and Australia-Asia Circa 1974-1984, revised June 1988.
DeVoretz, D.J. and Kjell G. Salvanes, Demand for Norwegian Farmed Salmon: A Market Penetration Model, July 1988.
Leitz, P., Real Price Projections for Leading Canadian Salmon Markets: 1985-2000, 1985.
Lin, Biing-Hwan, Mark Herrmann, Tsae-Yun Lin, and Ron C. Mittelnammer, Future Supply and Price of Norwegian Atlantic Salmon, Department of Agricultural Economics, University of Idaho, Research paper #263, September 1988.
Robinson, N., Estimation of the Price Elasticities of Demand for Canned Salmon by Species in the Canadian Retail Market, Economics 594 Graduating Essay, University of B.C., August 1987.

to the U.S. market. The other three papers (Robinson, DeVoretz 88 and DeVoretz and Salvanes) seek to measure demand elasticities and/or to test hypotheses about market structure.

The most commonly used functional forms for estimating demand are single equation price dependent, single equation quantity dependent and simultaneous with a supply equation. In most cases, demand from each market area (usually a country) is analyzed (for a species or product type) separately without considering the supply interrelationships between different markets. This is true for the Barnes, DeVoretz (1980)[1], Robinson and Leitz papers. The DeVoretz and Salvanes paper uses a four equation system to model demand and supply for Norwegian farmed salmon. The model includes equations for demand in a primary market and supply to the primary market, to all other markets and a supply identity. This model is quite specific to a hypothesized marketing strategy for Norwegian farmed salmon. Lin et. al. uses a seven equation model to analyze markets for Norwegian Atlantic salmon, including three structural equations relating to EEC demand, U.S. demand and U.S. supply, and four identities. Finally DeVoretz (1988), in which most reported results relate to single market areas, reports tests of two-market interrelationships between prices and quantities, and rejects such models on statistical grounds.

---

[1] Models are estimated for Canadian only, U.S. only , U.K. only, Canadian plus U.S. and all export (canned) markets. Different levels of aggregation in markets are also used in DeVoretz (1988).

There is a large range of estimated values of the own price, cross price and income elasticities in these studies, even for a specific species, product form and market. In many cases, equations are not statistically reliable enough to use and, if they are, confidence intervals on specific parameters are often unacceptably large. In other cases, great ranges in values are observed which cannot be fully explained on theoretical grounds based on the use of price dependent versus quantity dependent formulations and on differences in the data used. Finally, equations are often misspecified from a theoretical point of view because of the inclusion or exclusion of variables based on statistical goodness of fit, multicollinearity, etc.

Because of the wide range in values, the approach taken in this simulation model is to select initial values as plausible estimates found in the literature and then to use sensitivity analysis to test the effects of some of the more extreme values.

Own price elasticities:- With respect to canned markets, most of the estimates reviewed relate to the domestic market. DeVoretz (1980) obtains own price elasticities using a single equation (price dependent) model which range from -12.9 to -16.3 for canned sockeye, pink and chum. Use of a simultaneous (price dependent) model with a supply equation yields comparable estimates ranging from -10.4 to -12.9. Robinson (1987) argues that the DeVoretz values are overestimated due to the use of production data for a quantity variable along with a three year moving average for prices and that the use of a price dependent model also is likely to overestimate the own price elasticity. Robinson's own estimates (quantity dependent single equation) are -1.33 and -2.21 for canned domestic pink

and sockeye, respectively, and -1.32 and -2.80, respectively, using a simultaneous equation approach. Barnes (1987) obtains estimates for domestic canned which range from -4.22 to -10.10 for sockeye, pink and chum using a price dependent formulation. Corresponding quantity dependent values are -1.37 to -2.98.

Based on Robinson's arguments in favour of lower elasticities, a value of -2.0 is used for initial domestic canned own price parameters in our analysis.[1]

With respect to the canned export markets treated in our model, only the U.K. market is represented in the literature reviewed. DeVoretz (1980) obtains own price elasticities (single equation, quantity dependent) of -12.2 and -14.4 for canned sockeye and pink in the U.K. Later work by DeVoretz (1988) does not provide useable equations for these markets. It was thought that it would be inappropriate to use widely different own price elasticities based on different approaches for domestic and export markets. Accordingly, for the initial analysis, the domestic values are applied to all canned markets.

With respect to fresh/frozen markets, the available sources, although few in number, give a much narrower range of estimates of the own price elasticity. Barnes (1987) obtains values of -2.0 and -4.8 for frozen chinook and coho in the U.S. market, -3.7 for frozen chum

---

[1] Another reason to use relatively low own price elasticities in our model is that our formulation explicitly incorporates relative salmon price substitution effects. Own price elasticity estimates in models which do not take into account salmon product substitutes may incorporate some cross price, as well as own price effects.

in the Swedish market, and -3.2 and -6.4 for frozen chinook and coho, respectively, in the French market. Corresponding quantity dependent equations yielded estimates of -1.2 and -.46. DeVoretz (1988) obtains values of -2.9 for chum in the Swedish market and -.83 for coho in the French market. Initial values in our analysis assume own price elasticities of -2.0 for all species to represent the range of estimates given, and to reflect the considerations noted above for canned markets supporting a relatively low own price elasticity.

Cross-Price Elasticities:- Very little evidence is available with respect to cross price elasticities for substitute food products or substitute salmon products. Moreover, the estimates that are available are specific to the particular substitute (e.g. tuna, beef, etc.) used in the regression analyses.

In this analysis, substitute food products are defined very generally -- they refer to the basket of goods which make up the food component of the consumer price index. Because this price series is closely correlated with the overall CPI, the cross price effect here will in essence simply modify the own price effect. Consequently, a very low initial value (.002) is assumed. The reason here is not so much that substitution does not take place, but rather that it is assumed to be incorporated in the own price elasticity.[1]

---

[1] A rise in the price of alternative foods (and the CPI) is like a fall in the real price of the salmon products, the effect of which is captured in the own price elasticity of demand.

However, with respect to substitute salmon products, cross price effects are assumed. Initial values ranging from .1 to .8 are specified, with the higher end of the range reflecting greater substitutability between salmon species.

When specifying cross price parameters between two products, the relative size of the markets is considered to ensure that the estimates are consistent with one another. For example, if β_1 is the cross price elasticity of wild coho price on farmed coho demand and β_2 is the cross price elasticity of farmed coho on wild coho, β_1 and β_2 are related as follows:

$$\dot{D}_f = \beta_1 (\dot{p}_w - \dot{p}_f)$$

$$\dot{D}_w = \beta_2 (\dot{p}_f - \dot{p}_w)$$

$$\Rightarrow \text{for any given } \dot{p}_w$$

$$dD_f = \beta_1 \cdot \dot{pw} \cdot D_f$$

$$dD_w = -\beta_2 \dot{p}_w D_w$$

But $dD_f = -dD_w$

Therefore $\beta_1 \dot{p}_w D_f = \beta_2 \dot{p}_w D_w$

Therefore $\beta_1 = D_w/D_f \cdot \beta_2$

In other words, if the wild market is 10 times the size of the farmed market, the percentage effect of a change in wild coho prices on farmed demand will be 10 times the effect of a change in farmed coho prices on wild demand. This constraint is built into all of the cross

price parameter estimates, based on the initial quantities sold (at the outset of the forecast period) into each market.

Per Capita Income Elasticities:- Estimates of income elasticities vary markedly in the different studies. For example, in the Canadian market for canned sockeye, Robinson obtains income elasticity estimates which are negative and statistically significant, while DeVoretz 1980 obtains significant estimates ranging from 3.37 to 9.2. Other species and product forms display similar variations. There are several reasons for this. First, income is not consistently defined -- in some cases picking up the effect of changes in per capita income; in others picking up the combined effect of changes in per capita income and population. Second, the income variable may be picking up the effect of other factors which have been correlated with income trends over time -- for example, changing tastes.

In our formulation, changes in population cause a proportionate change in demand. Also, changes in tastes are explicitly modelled. Consequently, the per capita income variable is meant to capture changes in per capita consumption solely due to changes in per capita income. A relatively low initial value of .5 is assumed for this in all markets.

Taste Change:- Two effects can be included in this factor. Per capita demand for fish has generally been rising in response to the perceived health benefits of eating fish. In addition, the expansion of winter markets for fresh salmon due to aquaculture production can be viewed as a trend increase in annual per capita consumption. Little empirical evidence with respect to this parameter was provided in the studies we reviewed, though

it is generally acknowledged as an important factor in fresh/frozen and farmed markets. In the simulation this parameter is initially set at zero, but then increased in selected U.S. markets, based on past trends in per capita consumption of salmon. An increase of two percent per year is used for the farmed demand and an increase of one percent per year is used for wild fresh/frozen.

3.2 Supply-Related Parameters

Shrinkage rates by species and product form were derived from survey data obtained in 1985[1] along with assumptions regarding the mix of particular subspecies (e.g. red, pink and white chinook) and the proportions of fresh and frozen head-on vs. head-off sales.

3.3 Demand-Determining Variable Forecast

Forecasts of population growth in relevant countries (Canada, U.S., U.K., Sweden, France, Italy and Japan) were obtained from the Population Reference Bureau.[2] Forecast population growth rates range from zero percent for Italy to 1.1 percent for Canada. Per capita income forecasts were derived by assuming the average growth in income over the

---

[1] Fisheries Production Statistics of British Columbia 1985, Province of British Columbia, Ministry of Environment and Parks, p. 49-51.

[2] 1988 World Population Data Sheet, Population Reference Bureau, Inc. Point estimates for 1988 and 2000 were used to calculate an average annual growth rate.

last ten years to be continued into the future.[1] Resulting average forecast growth rates range from 1.5 percent (France) to 3.4 percent (Japan).

For initial runs, a constant real price forecast is used for other food substitutes and currently prevailing exchange rates are held constant over the forecast period.

3.4 Supply-Determining Variable Forecast

The allocation of B.C. landings by product type and by market destination was calculated using a DFO paper which forecasts market shares for B.C. salmon to the year 2000.[2] Forecast aquaculture production by country and species was obtained from background data to a 1988 paper.[3] For initial analysis, Norwegian farmed production was allocated by destination based on shares of 1988 production.

The supply of wild salmon from the rest of the world was assessed on a market by market basis. In many cases, supply from the U.S. is the only major competitor to Canadian

---

[1] A relatively long period was selected to smooth the effect of the business cycle.

[2] P.A. Leitz, Market Shares for Canadian Salmon Production 1985-2000, November, 1984.

[3] David Egan and Peter Leitz, Perspectives on Worldwide Salmon Supplies to the Year 2000, paper presented to Aquaculture International Congress and Exposition, September, 1988.

salmon. Forecasts of U.S. supply by species, product form, and destination were used for appropriate markets.[1] For Japanese markets, it is assumed that Japanese production of relevant species is largely consumed domestically, and along with U.S. supply, is the major competing supply to Canadian salmon. A forecast of Japanese landings by species to the year 2000 was provided by DFO.

In European markets, supplies of U.S. salmon and Norwegian aquaculture production were assumed to compete with Canadian products. Additional supplies to these markets were estimated from some recent historical data on imports by product type (for all species) into each country.[2] The proportion of non-U.S., non-Canadian wild supply into these markets was in all cases less than 12 percent of the total supply, and was forecast to continue at the existing share through the forecast period.

In preliminary runs using the supply data noted above, the model displayed substantial price instability for particular products and markets through time. This was due to great fluctuations from year to year in the forecasts of U.S. and Canadian supply into these markets combined with the fact that the current version of the model neither takes account of inventory fluctuations (which would dampen the price swings) nor allows supply to shift from market to market based on relative prices in the model. Accordingly, Canadian

---

[1] Peter A. Leitz, Market Shares for U.S. Salmon Production 1985-2000, November, 1984.

[2] DFO.

and U.S. wild supply forecasts by species, product form and market were assumed to be fixed over the forecast period at the average levels shown in the forecasts. This has the effect of making the model very "long run" in nature, indicating the impact of underlying trends in aquaculture supply, income and taste change, rather than the impact of fluctuating wild supply. It does not incorporate an increasing (or decreasing) trend in wild production, which could occur as a result of enhancement and/or management changes. This could easily be changed in future analyses with this model.

It should be noted that the percentages refer to the year to year changes. The absolute price level in any given year can be calculated by multiplying one plus the average change in that year by one plus the percentage change in each previous year by the initial price level.

4.0 RESULTS

4.1 Initial Run

The initial run results indicate the price changes one could expect with fixed wild supply to each market and growing farmed production, with a particularly sharp increase in Norwegian supply in 1990. The results incorporate the parameter and demand-determining variable forecasts as discussed above. The results are shown in Table 3, and summarized below.

Sockeye, pink and coho canned prices:- These are forecast to grow at an annual rate of .86 percent in the domestic market and .47 percent (for sockeye and pink) in the U.K. market. In all cases the rising prices are due to population and income growth, coupled with the assumed fixed supply. The higher domestic increase is due to higher forecast population and per capita income growth than in the U.K.

Sockeye fresh/frozen prices (Japan):- These are forecast to increase initially by .71 percent, rising to .99 percent/year by 1996. The lower price increase in the early years is due to increased farmed production of coho and Norwegian Atlantic salmon, which have some dampening price effects in that market.

TABLE 3
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH
BASE CASE

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.86%	0.47%	0.71%	0.86%	0.47%	0.71%	-5.01%	0.30%	0.69%
1991	0.86%	0.47%	0.93%	0.86%	0.47%	0.76%	-1.16%	0.30%	0.76%
1992	0.86%	0.47%	0.93%	0.86%	0.47%	0.76%	-1.03%	0.30%	0.76%
1993	0.86%	0.47%	0.93%	0.86%	0.47%	0.77%	-0.93%	0.30%	0.76%
1994	0.86%	0.47%	0.94%	0.86%	0.47%	0.77%	-0.84%	0.30%	0.77%
1995	0.86%	0.47%	0.94%	0.86%	0.47%	0.78%	-0.76%	0.30%	0.77%
1996	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.68%	0.30%	0.77%
1997	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.62%	0.30%	0.77%
1998	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.56%	0.30%	0.77%
1999	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.51%	0.30%	0.78%
2000	0.86%	0.47%	0.99%	0.86%	0.47%	0.78%	-0.46%	0.30%	0.78%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.86%	-1.22%	-13.89%	0.51%	0.86%	-2.06%	-9.30%	-13.74%	-15.85%
1991	0.86%	0.11%	-3.72%	0.51%	0.86%	-1.02%	-2.59%	-4.88%	-4.81%
1992	0.86%	0.16%	-3.38%	0.51%	0.86%	-0.93%	-2.40%	-4.03%	-4.46%
1993	0.86%	0.19%	-3.08%	0.51%	0.86%	-0.85%	-2.23%	-3.40%	-4.17%
1994	0.86%	0.38%	-2.83%	0.51%	0.86%	-0.77%	-2.08%	-2.48%	-2.61%
1995	0.86%	0.41%	-2.61%	0.51%	0.86%	-0.70%	-1.94%	-2.28%	-2.39%
1996	0.86%	0.43%	-2.42%	0.51%	0.86%	0.68%	-1.82%	-2.10%	-2.19%
1997	0.86%	0.45%	-2.24%	0.51%	0.86%	0.68%	-1.71%	-1.94%	-2.02%
1998	0.86%	0.47%	-2.09%	0.51%	0.86%	0.68%	-1.61%	-1.80%	-1.86%
1999	0.86%	0.49%	-1.96%	0.51%	0.86%	0.69%	-1.52%	-1.67%	-1.72%
2000	0.86%	0.50%	-1.83%	0.51%	0.86%	0.69%	-1.43%	-1.56%	-1.60%

Pink fresh/frozen prices (U.S.):- These are forecast to increase by .71 percent initially, rising to .78 percent/year by 1995. The lower initial price increase is due to weak cross price effects from other fresh/frozen markets in the U.S.

Chum fresh/frozen prices:- These are forecast to increase by .3 percent/year in Sweden and by .69 percent rising to .78 percent/year in the United States. In France they are forecast to fall by 5.01 percent initially and continue to fall at rates ranging from 1.16 percent to .46 percent in subsequent years. The falling price in France is due to competition from increased Norwegian supply.

Chinook fresh/frozen prices:- These are forecast to increase at annual rates of .86 percent in the domestic market and .51 percent in the Italian market, both due to population and income growth, combined with no assumed increase in competition from farmed production. In the U.S. market, a decline of 1.22 percent is forecast initially, followed by increases ranging from .11 percent to .5 percent in subsequent years. The initial reduction is due to the cross price impact of falling farmed prices. In the French market a decline of 13.89 percent is forecast initially, followed by declines of 3.72 percent to 1.83 percent in subsequent years. These reductions are due primarily to increases in Norwegian supply.

Coho fresh/frozen prices:- These are forecast to fall in the Japanese market by 2.06 percent initially and then by a lesser amount in subsequent years. By 1996 an increase of .68 percent per year is forecast. This price trend results from the impact of changing farmed

coho production in Japan. In the French market, the coho price is forecast to fall by 9.3 percent initially and then by rates of 2.59 percent to 1.43 percent per year in subsequent years. The reduction is due to the forecast impact of growing Norwegian supply to that market.

Farmed Coho and Chinook prices (U.S.): These are forecast to fall by 13.74 percent (coho) and 15.85 percent (chinook) initially and then by rates ranging from 4.8 percent to 1.6 percent in subsequent years. This results from the assumed increase in supply, with no assumed offsetting taste-driven increase in demand.

4.2 Sensitivity Analysis

The effect of changing assumptions on the price forecasts are described below.

1. **Higher Income Elasticity**:- Doubling the income elasticity from .5 to 1 increases the price forecast (or reduces the rate of decline) relative to the base case. As shown in Table 4, the impact is relatively small, changing the forecast change in price by the change in the income elasticity (.5) divided by the own price elasticity (2) times the forecast rate of growth in per capita income. In Canada, for example, that increases the price forecast by about .5 percent per year.

TABLE 4
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	1.36%	0.93%	1.58%	1.36%	0.93%	1.14%	-4.60%	0.64%	1.12%
1991	1.36%	0.93%	1.80%	1.36%	0.93%	1.20%	-0.75%	0.64%	1.19%
1992	1.36%	0.93%	1.80%	1.36%	0.93%	1.20%	-0.63%	0.64%	1.20%
1993	1.36%	0.93%	1.80%	1.36%	0.93%	1.20%	-0.52%	0.64%	1.20%
1994	1.36%	0.93%	1.80%	1.36%	0.93%	1.21%	-0.43%	0.64%	1.21%
1995	1.36%	0.93%	1.81%	1.36%	0.93%	1.21%	-0.35%	0.64%	1.21%
1996	1.36%	0.93%	1.85%	1.36%	0.93%	1.21%	-0.28%	0.64%	1.21%
1997	1.36%	0.93%	1.86%	1.36%	0.93%	1.21%	-0.21%	0.64%	1.21%
1998	1.36%	0.93%	1.86%	1.36%	0.93%	1.22%	-0.15%	0.64%	1.21%
1999	1.36%	0.93%	1.86%	1.36%	0.93%	1.22%	-0.10%	0.64%	1.21%
2000	1.36%	0.93%	1.86%	1.36%	0.93%	1.22%	-0.05%	0.64%	1.21%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	1.36%	-0.79%	-13.48%	1.02%	1.36%	-1.19%	-8.89%	-13.31%	-15.41%
1991	1.36%	0.55%	-3.32%	1.02%	1.36%	-0.15%	-2.19%	-4.44%	-4.37%
1992	1.36%	0.59%	-2.97%	1.02%	1.36%	-0.06%	-1.99%	-3.59%	-4.02%
1993	1.36%	0.63%	-2.68%	1.02%	1.36%	0.02%	-1.82%	-2.96%	-3.73%
1994	1.36%	0.82%	-2.42%	1.02%	1.36%	0.10%	-1.67%	-2.05%	-2.18%
1995	1.36%	0.84%	-2.20%	1.02%	1.36%	0.17%	-1.54%	-1.85%	-1.95%
1996	1.36%	0.87%	-2.01%	1.02%	1.36%	1.55%	-1.42%	-1.67%	-1.75%
1997	1.36%	0.89%	-1.84%	1.02%	1.36%	1.55%	-1.30%	-1.51%	-1.58%
1998	1.36%	0.91%	-1.69%	1.02%	1.36%	1.55%	-1.20%	-1.36%	-1.42%
1999	1.36%	0.92%	-1.55%	1.02%	1.36%	1.56%	-1.11%	-1.24%	-1.28%
2000	1.36%	0.94%	-1.43%	1.02%	1.36%	1.56%	-1.03%	-1.12%	-1.16%

Having a higher income elasticity for one product (e.g. sockeye: domestic canned), but not a competing product (e.g. pink: domestic canned), raises the forecast increase of sockeye prices, but by less than in the previous case. It also increases the forecast price of pink through cross price effects. For example, raising the sockeye income elasticity to 1, while holding the pink elasticity at .5, results in the sockeye price increasing by .46 percent per year and the pink price rising by .02 percent per year relative to the initial run results (when both elasticities were .5). This is based on cross price elasticities of .10 (sockeye-->pink) and .18 (pink -->sockeye). If the cross price elasticities were much higher (10 and 18), then sockeye and pink prices would increase by roughly the same amount -- in this case by .30 percent over the base case results for sockeye and .27 percent for pink.

2. **Higher own price elasticity**:- Raising the own price elasticities from -2 to -8 significantly dampens the change in prices for all products. The effect, shown in Table 5, is roughly proportional to the change in elasticity -- the four-fold increase in the elasticity generally reduces the rate of price change by a factor of one-quarter, though because of cross price effects this is not always the case. For example, whereas fresh/frozen chinook prices in the U.S. exhibited a 1.22 percent decline in 1990 in the base case, they show a marginal increase (.04 percent) with the higher elasticities. This occurs because farmed prices fall so much less in the high elasticity case.

TABLE 5
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.21%	0.12%	0.20%	0.21%	0.12%	0.20%	-0.41%	0.07%	0.20%
1991	0.21%	0.12%	0.24%	0.21%	0.12%	0.20%	-0.03%	0.07%	0.20%
1992	0.21%	0.12%	0.24%	0.21%	0.12%	0.20%	-0.02%	0.07%	0.20%
1993	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	-0.01%	0.07%	0.20%
1994	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.00%	0.07%	0.20%
1995	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.01%	0.07%	0.20%
1996	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.02%	0.07%	0.20%
1997	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.02%	0.07%	0.20%
1998	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.03%	0.07%	0.20%
1999	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.03%	0.07%	0.20%
2000	0.21%	0.12%	0.25%	0.21%	0.12%	0.20%	0.04%	0.07%	0.20%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.21%	0.04%	-3.60%	0.13%	0.21%	-0.54%	-2.31%	-3.40%	-4.11%
1991	0.21%	0.15%	-0.97%	0.13%	0.21%	-0.27%	-0.65%	-1.22%	-1.25%
1992	0.21%	0.15%	-0.87%	0.13%	0.21%	-0.25%	-0.60%	-1.00%	-1.16%
1993	0.21%	0.15%	-0.80%	0.13%	0.21%	-0.23%	-0.56%	-0.84%	-1.09%
1994	0.21%	0.17%	-0.73%	0.13%	0.21%	-0.21%	-0.52%	-0.62%	-0.68%
1995	0.21%	0.17%	-0.68%	0.13%	0.21%	-0.19%	-0.49%	-0.57%	-0.62%
1996	0.21%	0.17%	-0.62%	0.13%	0.21%	0.17%	-0.46%	-0.53%	-0.57%
1997	0.21%	0.17%	-0.58%	0.13%	0.21%	0.17%	-0.43%	-0.49%	-0.53%
1998	0.21%	0.17%	-0.54%	0.13%	0.21%	0.17%	-0.41%	-0.45%	-0.49%
1999	0.21%	0.18%	-0.51%	0.13%	0.21%	0.17%	-0.38%	-0.42%	-0.45%
2000	0.21%	0.18%	-0.47%	0.13%	0.21%	0.17%	-0.36%	-0.39%	-0.42%

A high own price elasticity for only one market area has a similar effect as in the case of the income elasticity. The price increase in the market is dampened, but not by as much as when all price elasticities are higher. Also, the price changes in competing products are dampened because of cross price effects.

3. **Taste Change**:- To test for the effect of the taste change factor, it was assumed that farmed per capita demand would increase by two percent per year and wild fresh/frozen demand would increase by one percent per year. These results are given in Table 6, and show a lower rate of price decline for farmed prices and a higher rate of price increase for the wild products. However, the impact is relatively small -- with the farmed prices falling approximately one percent less per year and the wild prices rising approximately .5 percent more per year relative to the base case.

4. **Higher Cross-Price Elasticity (Alternative Food)**:- Raising the alternative food cross price elasticity (results shown in Table 7) is very similar to raising the own price elasticity. It dampens the rate of price increase or decrease. An increase from .002 (negligible) to one reduces the rate of price increase by approximately one third. It should be noted that this result reflects the forecast of no real change in alternative food prices. The significance of the higher cross elasticity would vary if alternative food prices were rising or falling in real terms.

TABLE 6
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.86%	0.47%	0.71%	0.86%	0.47%	0.75%	-5.01%	0.30%	1.17%
1991	0.86%	0.47%	0.93%	0.86%	0.47%	0.80%	-1.16%	0.30%	1.24%
1992	0.86%	0.47%	0.93%	0.86%	0.47%	0.80%	-1.03%	0.30%	1.24%
1993	0.86%	0.47%	0.93%	0.86%	0.47%	0.81%	-0.93%	0.30%	1.24%
1994	0.86%	0.47%	0.94%	0.86%	0.47%	0.81%	-0.84%	0.30%	1.25%
1995	0.86%	0.47%	0.94%	0.86%	0.47%	0.81%	-0.76%	0.30%	1.25%
1996	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.68%	0.30%	1.25%
1997	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.62%	0.30%	1.25%
1998	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.56%	0.30%	1.26%
1999	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.51%	0.30%	1.26%
2000	0.86%	0.47%	0.99%	0.86%	0.47%	0.82%	-0.46%	0.30%	1.26%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.86%	-0.69%	-13.89%	0.51%	0.86%	-2.06%	-9.30%	-12.75%	-14.87%
1991	0.86%	0.65%	-3.72%	0.51%	0.86%	-1.02%	-2.59%	-3.88%	-3.83%
1992	0.86%	0.69%	-3.38%	0.51%	0.86%	-0.93%	-2.40%	-3.03%	-3.48%
1993	0.86%	0.73%	-3.08%	0.51%	0.86%	-0.85%	-2.23%	-2.40%	-3.19%
1994	0.86%	0.92%	-2.83%	0.51%	0.86%	-0.77%	-2.08%	-1.49%	-1.64%
1995	0.86%	0.94%	-2.61%	0.51%	0.86%	-0.70%	-1.94%	-1.29%	-1.41%
1996	0.86%	0.97%	-2.42%	0.51%	0.86%	0.68%	-1.82%	-1.11%	-1.21%
1997	0.86%	0.99%	-2.24%	0.51%	0.86%	0.68%	-1.71%	-0.95%	-1.04%
1998	0.86%	1.01%	-2.09%	0.51%	0.86%	0.68%	-1.61%	-0.80%	-0.88%
1999	0.86%	1.03%	-1.96%	0.51%	0.86%	0.69%	-1.52%	-0.68%	-0.74%
2000	0.86%	1.04%	-1.83%	0.51%	0.86%	0.69%	-1.43%	-0.56%	-0.62%

TABLE 7
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.57%	0.31%	0.50%	0.57%	0.31%	0.50%	-2.58%	0.20%	0.49%
1991	0.57%	0.31%	0.63%	0.57%	0.31%	0.52%	-0.54%	0.20%	0.52%
1992	0.57%	0.31%	0.63%	0.57%	0.31%	0.52%	-0.47%	0.20%	0.52%
1993	0.57%	0.31%	0.64%	0.57%	0.31%	0.52%	-0.42%	0.20%	0.52%
1994	0.57%	0.31%	0.64%	0.57%	0.31%	0.52%	-0.37%	0.20%	0.52%
1995	0.57%	0.31%	0.64%	0.57%	0.31%	0.52%	-0.33%	0.20%	0.52%
1996	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.29%	0.20%	0.52%
1997	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.25%	0.20%	0.52%
1998	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.22%	0.20%	0.52%
1999	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.19%	0.20%	0.52%
2000	0.57%	0.31%	0.66%	0.57%	0.31%	0.52%	-0.17%	0.20%	0.52%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.57%	-0.45%	-9.40%	0.34%	0.57%	-1.40%	-6.18%	-9.13%	-10.74%
1991	0.57%	0.20%	-2.52%	0.34%	0.57%	-0.70%	-1.73%	-3.26%	-3.26%
1992	0.57%	0.22%	-2.28%	0.34%	0.57%	-0.64%	-1.60%	-2.68%	-3.02%
1993	0.57%	0.24%	-2.08%	0.34%	0.57%	-0.58%	-1.49%	-2.25%	-2.83%
1994	0.57%	0.33%	-1.91%	0.34%	0.57%	-0.53%	-1.39%	-1.66%	-1.77%
1995	0.57%	0.34%	-1.76%	0.34%	0.57%	-0.48%	-1.30%	-1.52%	-1.62%
1996	0.57%	0.35%	-1.63%	0.34%	0.57%	0.45%	-1.22%	-1.40%	-1.49%
1997	0.57%	0.36%	-1.52%	0.34%	0.57%	0.45%	-1.14%	-1.30%	-1.37%
1998	0.57%	0.37%	-1.41%	0.34%	0.57%	0.45%	-1.08%	-1.20%	-1.26%
1999	0.57%	0.38%	-1.32%	0.34%	0.57%	0.46%	-1.01%	-1.12%	-1.17%
2000	0.57%	0.39%	-1.24%	0.34%	0.57%	0.46%	-0.96%	-1.04%	-1.09%

5. **Cross Price Elasticity (Farmed/Wild Chinook U.S.):-** The base case assumed .1 (wild-->farmed) and .3 (farmed-->wild) U.S. chinook cross price elasticities. Had there been no cross price elasticity, as shown in Table 8, the wild chinook prices would have been higher (increasing over the entire period at .79 percent/year) and the farmed chinook prices would have fallen more sharply (initially by 16.55 percent and then by 5.04 percent to 1.7 percent in subsequent years). On the other hand, had the cross price elasticities been higher, farmed prices would have fallen by less and wild prices would have fallen instead of risen. For example, as given in Table 9, at a cross price elasticity of 10 (wild-->farmed) and 30 (farmed-->wild), wild prices would have initially fallen by 11.43 percent and then by 3.32 percent to .96 percent in subsequent years. Farmed prices would initially have fallen by 12.31 percent and then by 3.62 percent and 1.09 percent in subsequent years. At markedly higher cross elasticities, the price trends would have moved even closer together, both falling at just over 12 percent initially and then by 3.5 percent to just over one percent in subsequent years.

TABLE 8
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.86%	0.47%	0.71%	0.86%	0.47%	0.79%	-5.01%	0.30%	0.79%
1991	0.86%	0.47%	0.93%	0.86%	0.47%	0.79%	-1.16%	0.30%	0.79%
1992	0.86%	0.47%	0.93%	0.86%	0.47%	0.79%	-1.03%	0.30%	0.79%
1993	0.86%	0.47%	0.93%	0.86%	0.47%	0.79%	-0.93%	0.30%	0.79%
1994	0.86%	0.47%	0.94%	0.86%	0.47%	0.79%	-0.84%	0.30%	0.79%
1995	0.86%	0.47%	0.94%	0.86%	0.47%	0.79%	-0.76%	0.30%	0.79%
1996	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.68%	0.30%	0.79%
1997	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.62%	0.30%	0.79%
1998	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.56%	0.30%	0.79%
1999	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.51%	0.30%	0.79%
2000	0.86%	0.47%	0.99%	0.86%	0.47%	0.79%	-0.46%	0.30%	0.79%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.86%	0.79%	-13.89%	0.51%	0.86%	-2.06%	-9.30%	-13.82%	-16.55%
1991	0.86%	0.79%	-3.72%	0.51%	0.86%	-1.02%	-2.59%	-4.90%	-5.04%
1992	0.86%	0.79%	-3.38%	0.51%	0.86%	-0.93%	-2.40%	-4.05%	-4.68%
1993	0.86%	0.79%	-3.08%	0.51%	0.86%	-0.85%	-2.23%	-3.42%	-4.38%
1994	0.86%	0.79%	-2.83%	0.51%	0.86%	-0.77%	-2.08%	-2.50%	-2.76%
1995	0.86%	0.79%	-2.61%	0.51%	0.86%	-0.70%	-1.94%	-2.30%	-2.52%
1996	0.86%	0.79%	-2.42%	0.51%	0.86%	0.68%	-1.82%	-2.12%	-2.32%
1997	0.86%	0.79%	-2.24%	0.51%	0.86%	0.68%	-1.71%	-1.96%	-2.13%
1998	0.86%	0.79%	-2.09%	0.51%	0.86%	0.68%	-1.61%	-1.81%	-1.97%
1999	0.86%	0.79%	-1.96%	0.51%	0.86%	0.69%	-1.52%	-1.68%	-1.83%
2000	0.86%	0.79%	-1.83%	0.51%	0.86%	0.69%	-1.43%	-1.57%	-1.70%

TABLE 9
SALMON PRODUCT
PRICE TRENDS
RATES OF REAL GROWTH

	Sockeye Canned Domestic	Sockeye Canned U.K.	Sockeye Fr/Frozen Japan	Pink Canned Domestic	Pink Canned U.K.	Pink Fr/Frozen U.S.	Chum Fr/Frozen France	Chum Fr/Frozen Sweden	Chum Fr/Frozen U.S.
1990	0.86%	0.47%	0.71%	0.86%	0.47%	0.28%	-5.01%	0.30%	0.15%
1991	0.86%	0.47%	0.93%	0.86%	0.47%	0.62%	-1.16%	0.30%	0.58%
1992	0.86%	0.47%	0.93%	0.86%	0.47%	0.63%	-1.03%	0.30%	0.59%
1993	0.86%	0.47%	0.93%	0.86%	0.47%	0.64%	-0.93%	0.30%	0.60%
1994	0.86%	0.47%	0.94%	0.86%	0.47%	0.69%	-0.84%	0.30%	0.66%
1995	0.86%	0.47%	0.94%	0.86%	0.47%	0.69%	-0.76%	0.30%	0.67%
1996	0.86%	0.47%	0.99%	0.86%	0.47%	0.70%	-0.68%	0.30%	0.68%
1997	0.86%	0.47%	0.99%	0.86%	0.47%	0.70%	-0.62%	0.30%	0.68%
1998	0.86%	0.47%	0.99%	0.86%	0.47%	0.71%	-0.56%	0.30%	0.69%
1999	0.86%	0.47%	0.99%	0.86%	0.47%	0.71%	-0.51%	0.30%	0.70%
2000	0.86%	0.47%	0.99%	0.86%	0.47%	0.72%	-0.46%	0.30%	0.70%

	Chinook Fr/Frozen Domestic	Chinook Fr/Frozen U.S.	Chinook Fr/Frozen France	Chinook Fr/Frozen Italy	Coho Canned Domestic	Coho Fr/Frozen Japan	Coho Fr/Frozen France	Farmed Coho U.S.	Farmed Chinook U.S.
1990	0.86%	-11.43%	-13.89%	0.51%	0.86%	-2.06%	-9.30%	-13.38%	-12.31%
1991	0.86%	-3.32%	-3.72%	0.51%	0.86%	-1.02%	-2.59%	-4.75%	-3.62%
1992	0.86%	-3.06%	-3.38%	0.51%	0.86%	-0.93%	-2.40%	-3.91%	-3.34%
1993	0.86%	-2.85%	-3.08%	0.51%	0.86%	-0.85%	-2.23%	-3.29%	-3.12%
1994	0.86%	-1.71%	-2.83%	0.51%	0.66%	-0.77%	-2.08%	-2.41%	-1.89%
1995	0.86%	-1.54%	-2.61%	0.51%	0.86%	-0.70%	-1.94%	-2.21%	-1.71%
1996	0.86%	-1.40%	-2.42%	0.51%	0.86%	0.68%	-1.82%	-2.04%	-1.56%
1997	0.86%	-1.27%	-2.24%	0.51%	0.86%	0.68%	-1.71%	-1.88%	-1.42%
1998	0.86%	-1.16%	-2.09%	0.51%	0.86%	0.68%	-1.61%	-1.74%	-1.30%
1999	0.86%	-1.05%	-1.96%	0.51%	0.86%	0.69%	-1.52%	-1.62%	-1.19%
2000	0.86%	-0.96%	-1.83%	0.51%	0.86%	0.69%	-1.43%	-1.50%	-1.09%